EXECUTIVE SUMMARY

Purpose

The Major Lakes and Streams Monitoring Programs are designed to protect the significant investment in water quality improvement and protection made by the people of King County. At one time, sewage and wastewater were discharged directly into lakes Washington, Union, and Sammamish. Sewage and wastewater now enter secondary treatment facilities at West Point and Renton. From there, treated water is discharged into the well-mixed waters of Puget Sound. While the diversion of sewage has resulted in dramatic improvements in lake water quality, monitoring water quality is still important.

The present monitoring program is designed to protect the significant investment in water quality improvement and protection made by the people of King County. Sewage and wastewater effluent that used to be discharged directly into the county's lakes and streams is collected and transferred to treatment plants that discharge to Puget Sound. A major function of the monitoring program is to evaluates the efficacy of the sewage collection and transfer system on the protection and improvement of the regional water quality.

With the removal of most direct – or "point" – sources of sewage effluent, non-point source pollution related to urbanization currently has the greatest impact on water quality. The long-term environmental impacts of non-point pollution on the quality of lakes and streams can only be evaluated by sampling at multiple sites throughout the watershed.

This report covers data collected at 20 sites, primarily in the northern Lake Washington basin. The objectives of this effort were to: analyze data for long-term water quality trends; determine compliance with State and Federal water quality criteria; evaluate the level of metals in stormwater and sediments; compare baseflow with storm event sampling; and characterize the general water quality of the streams.

Monitoring and Analysis

This report focuses on the 16 sites on the northern Lake Washington tributaries including the Sammamish River, and four sites in the Soos Creek Basin (Table ES-1). Monthly baseflow samples were collected beginning in 1979. The Soos Creek basin sites were evaluated as an element of the County's Stormwater National Pollution Discharge Elimination System (NPDES) effectiveness evaluation completed for the fourth annual report to the state Department of Ecology. The period of record for most sites and parameters was 20 years (Table ES-2).

Storm monitoring efforts focus on sampling storms spread throughout the wet season (October – May). Beginning in 1987, storm samples were collected three to six times annually at sites located at the mouth of selected streams. The mouth of the Sammamish River was not sampled during storm events. Storm samples were analyzed for the same parameters as baseflow samples plus trace metals. In addition, sediment samples were collected annually at these same eight locations.

Table ES-1. Sampling and Gauge Locations, Drainage Area (square miles), and Number of Sample Events

Stream	Drainage area (mi^2)	Locator	Gauge	Baseline	Storm	Sediment
Lyon	3.7	0430	34A	238	30	12
McAleer	7.8	A432	35D	242	47	12
Thornton	12.1	0434	58B	237	30	12
Sammamish River						
at Kenmore		0450		230		
at Marymoor		0486		230		
Swamp	23	0470	56A	236	27	12
North	27	0474		234	27	12
Little Bear	15.3	0478	30A	240	28	12
Bear-Evans	48.2					
at Mouth		0484	02J	235		
at N.E. 95th St.		C484		238		
at 19500 Seidel Rd.		J484		234		
Cottage Creek		N484		234		
Evans at Bear		B484		278		
Upstream Evans		S484		218		
Juanita Creek	6.7					
at Mouth		0446	27A	236	47	12
at 124th St		C446		237		
Soos	66.7					
above Hatchery		A320	54A	233	47	12
Covington		C320		239		
Jenkins		D320		232		
Little Soos		G320		228		

Table ES-2. Number of stream measurements for selected parameters between 1976 and 1999.

PARAMETER	BASEFLOW	STORM	SEDIMENT
Flow	2,605	136	
Conventionals			
• Dissolved oxygen	4,574	313	
• Temperature	4,940	328	
• Turbidity	4,800	330	
• Total Suspended Solids	4,817	330	
• PH	4,429	305	
• Conductivity	4,807	327	
Nutrients			
• Ortho Phosphorus	4,654	330	
• Total Phosphorus	4,474	330	
• Ammonia Nitrogen	3,966	287	
• Nitrate + Nitrite	4,738	330	
• Total Nitrogen	1,626	210	
Bacteria			
• Enterococcus	2,649	325	
• Fecal coliform bacteria	4,815	330	
Trace Metals			
• Cadmium	0	2,520	672
• Copper	0	2,520	672
• Lead	0	2,520	672
• Mercury	0	2,520	672
• Nickel	0	2,520	672
• Silver	0	2,520	672
• Zinc	0	2,520	672

Summary of Findings

In addition to the natural features of the watersheds, the primary factors affecting water quality in the region are weather and general land use. Regional rainfall and temperatures affect local surface waters and influence water quality. Land use determines potential non-point pollution from various sources.

There have been several trends in water quality parameters over the last 20 years. Due to natural variability of environmental data, these trends would not likely have been discernable over a shorter period of record. Significant long-term trends are summarized in the following list:

- Dissolved oxygen concentrations have declined since 1990 at the mouth of Swamp Creek and at both monitoring sites on Evans Creek.

- Stream temperatures have shown an increasing trend at 18 of the 20 sites between 1979 and 1999.

- pH has been decreasing since 1979 in Thornton Creek, the mouth of the Sammamish River, Swamp Creek, McAleer Creek, and at both sampling sites on Evans Creek.

- An increasing trend in conductivity values was experienced at all sites except for upper Evans Creek from 1979 to 1999.

- Suspended solids have been decreasing under baseflow conditions on Little Soos Creek.

- In general, ammonia-nitrogen concentrations were higher in the fall and winter and have shown an increasing trend on the mainstem of Bear-Evans Creek, Cottage Creek, upstream Evans Creek, Covington Creek, and at the mouth of McAleer Creek since 1979.

- Nitrate concentrations at Covington and Jenkins Creeks in the Soos Basin have increased since 1979.

- Fecal coliform bacteria levels decreased between 1979 and 1999 at 16 of the 20 sites reported here, however, none of the sites in this report met state criteria for fecal coliform bacteria.

- Total phosphorus concentrations have decreased between 1979 and 1999 at Juanita Creek, the mouth of the Sammamish River, Swamp Creek, and North Creek, several sites in the Bear-Evans Creek, Cottage Creek, and the mouth of Evans Creek.

Findings Report

Dissolved oxygen concentrations have declined since 1990 at the mouth of Swamp Creek and at both sites on Evans Creek. The highest number of state criteria violations for dissolved oxygen concentrations were measured at these two creeks. Most of these violations occurred during the summer dry season, implicating low flows and high temperatures as the primary factors influencing the low oxygen concentrations. Greater than 95 percent of the dissolved oxygen samples at all of the other stream sites were above the State standard of 9.5 mg/L. Storm samples collected at the mouth of Swamp Creek violated dissolved oxygen criteria in three of the 26 samples. The reason for this declining trend is undetermined. Although concentrations of dissolved oxygen at these two sites remains lower than most other sites, time series plots indicate concentrations may be increasing again, though not yet at levels considered statistically significant.

Stream temperatures have shown an increasing trend at 18 of the 20 sites between 1979 and 1999. Increases may be associated with removal of riparian vegetation and increasing impervious surfaces due to urbanization, or changes in regional climate conditions.

Suspended solids are decreasing under baseflow conditions on Little Soos Creek. This decline in suspended solids may be the result of changes in land use a short distance upstream of the sampling site, where small hobby farms no longer keep livestock near the creek. Poor animal keeping practices can result in the destruction of riparian buffer zones and increased sediment and fecal matter washing into surface waters.

pH has been decreasing since 1979 in Thornton Creek, the mouth of the Sammamish River, Swamp Creek, McAleer Creek, and at both sampling sites on Evans Creek. Increased urbanization and the resulting increased stormwater runoff may have contributed to this decline in pH. Low pH can promote other water quality problems such as increased solubility of metals and increased toxicity at lower pH values. At lower pH values, nutrients are more soluble and more readily available to phytoplankton and aquatic plants.

Conductivity values have increasing at all sites except for upper Evans Creek from 1979 to 1999. These increases are likely a result of increased urbanization.

Since 1979, ammonia-nitrogen concentrations were generally higher in the fall and winter and have shown an increasing trend on the mainstem of Bear-Evans Creek, Cottage Creek, upstream Evans Creek, Covington Creek, and at the mouth of McAleer Creek. No cause for the increase was determined.

Nitrate+nitrite-nitrogen concentrations are highest in the winter. There has been an increase in nitrate concentrations at Covington and Jenkins Creeks in the Soos Basin since 1979. No cause for the increase was determined.

Total phosphorus concentrations have decreased between 1979 and 1999 at several sites: Juanita Creek, the mouth of the Sammamish River, Swamp Creek, and North Creek, several sites in the Bear-Evans Creek, Cottage Creek and the mouth of Evans Creek. increased implementation of "best management practices" (e.g., erosion control during construction, etc.) may be a contributing factor to the decrease in concentrations.

Ortho-phosphorus (ortho-p) concentrations are generally higher April through August. Between 1979 and 1999 there was a decrease in ortho-P concentrations at the mouth of the Sammamish River and at North and Swamp creeks. As with total phosphorus, implementation of best management practices (BMPs) may be resulting in lower measured concentrations.

Fecal coliform bacteria levels decreased between 1979 and 1999 at 16 of the 20 sites reported here, though none of the sites in this report met state criteria for fecal coliform bacteria. The most dramatic decrease was measured at North Creek, Little Soos Creek, and the mouth of Bear Creek. Implementation of best management practices and changes in land use from hobby and commercial farming may have resulted in lower bacteria counts. Studies in urbanized Thornton Creek have identified humans as a minor source of the very high fecal bacteria counts common in this stream.

Trace metals in both the water and the sediments usually met the EPA criteria when the comparisons could be made. Relatively high detection levels for past analytical techniques made comparisons to the criteria impossible. Current analytical methods have lower detection limits that will allow for better comparisons to criteria and trend analysis in the future.

Analysis and Discussion

A recent Puget Sound lowland stream study concluded that physical, chemical, and biological characteristics of streams change with increasing urbanization in a continuous rather than a threshold fashion (May et al., 1997). The study found that the altered watershed hydrologic regime was the leading cause for the overall changes observed in instream physical habitat conditions. In contrast to the physical habitat, water quality constituents and sediment metal concentrations did not follow this pattern, changing little until the urbanization gradient approached 40 percent total impervious area (TIA). Even then, the water column concentrations did not violate state and federal aquatic life criteria and sediment concentrations remained far below guidelines. After the extent of urbanization exceeded 50 percent TIA, most pollutant concentrations rose rapidly, and their role become more important biologically.

Since 1976 the water quality measured at most county sites has been affected by development as indicated by increases in temperature and conductivity, and decreases in pH. It may be that some of the impacts resulting from increased land development in the last two decades were mitigated by improved implementation of various BMPs as indicated by the observed decreasing trends in total phosphorus and fecal coliform bacteria.

However, the use of water quality constituents and sediment concentrations may not be the most appropriate indicators to use when trying to quantify impacts to the streams from urbanization. If the role of pollutant concentrations becomes measurably important to the biological integrity of a stream only after the % TIA reached 50 percent (May et al., 1997), then the full extent of urbanization on concentrations of chemical constituents in many of King County streams may not yet be fully realized.

The timing and extent of land-use changes affect water quality, biological indicators of stream health. The timing and extent of land use change helps to interpret long-term trends in water chemistry (i.e., declines in phosphorus and fecal bacteria due to upgraded infrastructures and reduction of hobby farms) and potential impacts to the biota. Geographically explicit temporal mapping of each stream basin showing the changes in percent impervious area needs to be done for each sub-watershed. Including benthos data along with stream habitat, percent total impervious area, and water quality chemistry will provide a better indication of the overall biological integrity of the stream, and identify stressors to impacted streams.

Trace metals have not been shown to be a widespread problem in the streams covered in this report. Comparisons to state and federal criteria were not possible due to the relatively high detection limits of analytical techniques used until 1993. Current analytical methodologies have much lower detection limits and will allow for better comparisons. As the length of the data record increases, trend analysis for metals in water and sediment can be included.

There was an increase in water temperature from 1979 to 1999 at nearly all of the sites included in this report. It is difficult to determine whether this trend is the result of urbanization, regional climatic cycles, degradation of the riparian zone, or a combination of these factors. The Puget Sound Lowland study (May et al., 1997) found that a key determinant of the biological integrity of a stream appears to be the quality and quantity of the riparian zone available to buffer the stream ecosystem from negative influences in the watershed. Comprehensive habitat assessments of major tributaries should be prioritized and completed as was done for with the Habitat Inventory and Assessment for North, Swamp and Little Bear Creeks (King County WLRD, 2001) and Juanita Creek (King County WLRD report due in spring 2002). These assessments determine the extent of riparian vegetation and impervious area in the drainage basin. This work should be coordinated with other habitat assessment groups. Likewise, regional climatic cycles should be evaluated to determine their influence of any observed water quality trends.

None of the sites in this report met the state criteria for fecal coliform bacteria. Other work suggests most of the fecal material found in surface water is often related to increased development and the subsequent increases in the localized density of pets. In addition, poor animal keeping practices are known to increase bacteria levels in soil and surface waters. In some locations, the primary bacteria sources are waterfowl whose populations have increased dramatically in recent years. Source tracing should be carried out at several, if not all, of the sites with chronically high bacterial counts.

Preliminary source tracing was conducted in the Thornton Creek, McAleer Creek, and Lyon Creek watersheds in 2001. As part of that effort, a microbial source tracking survey was conducted in the Thornton Creek watershed. Similar to what was found in Juanita Creek in 1998, the preponderance of identifiable bacterial isolates was traced to birds and dogs. About 3 percent of the *E. coli* isolate matches were to humans, unlike the Juanita Creek survey, which had no matches to human sources.

Bacterial contamination is a major water quality issue for King County that is not limited to the streams in this report. While the identified load from human sources are a far smaller than from other animal sources, the public health implications are far greater, and represent the greatest challenge to restoring the natural environment and protecting public health and safety. Bacterial contamination from non-human sources also has public health concerns, and indicates non-point pollution sources. If pollution sources are identified, corrective actions can potentially be carried out to reduce the impact to regional water quality.

The key issue facing King County streams in the 1978 Area wide Water Quality Plan and the 1987 Priorities for Water Quality Report – "aquatic habitat degradation" – remains a key issue today. Much research since 1979 has focused on stormwater management and impacts to streams due to increased urbanization. In particular, the Puget Sound Lowland Stream Study found "that there is a set of necessary, though not by themselves sufficient, conditions required to maintain a high level of stream quality or ecological integrity. If maintenance of that level is the goal, then this set of enabling conditions constitutes standards that must be achieved if the goal is to be met" (May et al., 1997). For most county streams, imperviousness must be limited (<5-10% TIA), unless mitigated by extensive riparian corridor protection and stormwater management. Otherwise we will need to acknowledge that fish runs will disappear, water quality will degrade, and the probability of flooding will increase. Downstream changes to both the form and function of stream systems are inevitable unless significant changes are made in the way urban development occurs. King County adopted more stringent stormwater management requirements in 1998 with the adoption of the King County Surface Water Design Manual. There are some indications that these requirements have been effective in mitigating some of the impacts of urbanization. But there are also indications that these efforts are insufficient to correct many of the impacts and protect the natural environment and public health and safety.

Recommendations

The following list summarizes recommendations that will assist King County staff in the characterization of water quality conditions of these, and other, King County streams:

1. Bacteria source identification and control studies should be conducted at sites with chronically high bacteria counts.

2. Geographically explicit mapping of current land cover should be done for each stream drainage area, and a model developed to project geographically explicit future land cover.

3. Habitat assessments and inventories should be prioritized and coordinated with other groups such as Water Resource Inventory Area (WRIA) technical teams and the Adopt-A-Stream Foundation.

4. Benthic invertebrate monitoring should be continued at all routine monitoring sites. Comparison of current with previous benthos studies could illustrate any degradation that may have taken place over time.

5. Water quality trends should be incorporated into regional climatic studies to examine rainfall and temperature cycles since 1970 and evaluate potential future impacts of possible climate change.

6. The current, or an improved, monitoring regime should continue in order to track long-term changes and trends in water quality.

7. Monitoring efforts should be coordinated with Snohomish County for a comprehensive look at tributaries that cross the King-Snohomish county line (i.e., North, Swamp, etc.). This could include the use of similar methodologies, coordinated timing of data collection, as well as shared data for analysis and reporting.

Conclusion

Preservation of high-quality stream systems through the use of land use controls, riparian buffers, and protection of critical habitat should be a priority. However, the correction of water quantity and quality problems in the urban streams is also a priority. Enhancement and mitigation efforts should be focused on watersheds where ecological function is impaired but not entirely lost.